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(71)Applicant : NIKON CORP
(72)Inventor : MATSUMOTO KOICHI

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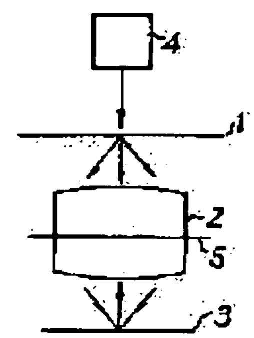
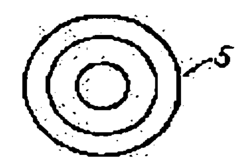
(54) ALIGNER

(57)Abstract:
PURPOSE: To obtain an aligner capable of obtaining a high contrast image of a fine pattern.
CONSTITUTION: An illumination optical system 4 is preferably constituted as ring belt illumination wherein the central part of a light source is shielded, and transparently illuminates a photo mask 1 in which a pattern is formed, with exposure light having a specified wavelength. A projection optical system 2 is installed below the photo mask 1. On the pupil surface of the projection optical system 2, a polarization member 5 is arranged, which transmits only the light whose electric vector oscillates in the direction parallel to the sides of the pattern of the photo mask 1. Diffracted light generated by transparently illuminating the photo mask 1 is collected by the projection optical system 2, and converted into a TE polarization light wherein oscillation direction of the electric vector is uniform, by the polarization member 5, thereby forming a pattern image on an image surface 3.

(a)



(b)



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(71) Applicant: 000004112
K.K. Nikon
(Address Not Translated)

(72) Inventor: Matsumoto Koichi
(Address Not Translated)

(54) [Title of Invention] ALIGNER

(57) [Abstract]

[Problem] The invention seeks to provide an aligner capable of obtaining a high-contrast image of a fine pattern.

[Solution] An illumination optical system 4 is preferably constructed as ring beltannular illumination wherein the central pat of a light source is shielded, and transparently illuminates a photo mask 1 in which a pattern is formed with exposure light having a specified wavelength. A projection optical system 2 is installed below the photo mask 1. On the pupil surfacepupil plane of the projection optical system 2, a polarization member 5 is arranged, which transmits only the light of which an electric vector oscillates in a direction parallel to sides of the pattern of the photo mask 1. Diffracted light generated by transparently illuminating the photo mask is collected by the projection optical system 2, and converted into a TE polarization light in which the

oscillation direction of an electric vector is uniform by the polarization member 5, so that a pattern image is formed on an image surface 3.

Figs. 1(a) and 1(b)

[Claims]

[Claim 1] An aligner having a projection optical system that projects a pattern on a photo mask, the aligner comprising a polarization member, arranged approximately on a pupil surfacepupil plane of the projection optical system, for transmitting light of which an electric vector oscillates in a direction parallel to sides of the pattern.

[Claim 2] The aligner of claim 1, wherein the polarization member transmits only the light of which the electric vector oscillates in a direction of a tangent line of a circle centering around an optical axis of the projection optical system.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Belongs]

The present invention relates to an aligner used to transfer an image of a circuit pattern formed on a photo mask onto a wafer surface in a lithography process for manufacturing semiconductor devices.

[0002]

[Prior Art]

In a lithography process for manufacturing semiconductor devices, generally used aligner has the construction as illustrated in FIG. 3. In the drawing, a photo mask 21 is horizontally maintained to be transverse to an optical axis of an illumination optical system 24, and is transparently illuminated by an exposure light having a specified wavelength emitted from the illumination optical system 24. The photo mask 21 having been conventionally used has the structure in which a shield pattern made of metal such as chrome and so on is formed on a transparent substrate, and is transparently illuminated to generate diffracted light according to the shape of the pattern. The diffracted light is collected again on an image surface 23 by a projection optical system 22, and this causes a pattern image of the photo mask 21 to be transferred onto a wafer surface maintained to be in accord with an image forming surface. In this case, since a polarization member is not included in the projection optical system of the conventional aligner, the light collected on the image surface 23 is in a state that no polarization characteristic exists, i.e., in an average state of TE (Transverse Electric) polarization (to be described later) and TM (Transverse Magnetic) polarization.

[0003]

[Problem to be Solved by the Invention]

With the conventional aligner as described above, however, it is impossible to cope with a fine circuit pattern according to the high density integration of a semiconductor device, and there exists a need for the development of technology that makes it possible to form a high-contrast image of a fine pattern. As methods for heightening the contrast on a pattern, several phase shift methods have recently been proposed, which perform projection exposure using a phase shift mask having a phase shift part installed in a specified place of a light transmission part of a photo mask to change the phase of a transmitted light. For example, Japanese Patent Laid-open No. Sho 62-50811 discloses a technique related to a spatial frequency modulation type phase shift mask. This technique forms a pattern image using phase information of light in addition to amplitude information of the light. For example, this technique achieves somewhat improvement of the image forming performance in comparison to a method that used a photo mask composed of a light transmission part (e.g., naked surface part of a substrate) and a light shield part only.

[0004]

However, this phase shift method itself has limitations, and fails to provide a satisfactory high-contrast image of the fine pattern. The present invention has been developed in order to substantially solve the above and other problems associated with the conventional arrangement. An object of the present invention is to provide an aligner which can realize a high-resolution, high-contrast image forming performance using third information except for the amplitude and the phase of light and thus can make it possible to seek a new development of the photolithography technology.

[0005]

[Means for Solving the Problem]

An aligner according to the present invention is provided with a projection optical system that projects a pattern onto a photo mask, and in order to solve the above-described problems, it comprises a polarization member arranged approximately on a pupil surfacepupil plane of the projection optical system to transmit light of which an electric vector oscillates in a direction parallel to sides of the pattern.

[0006]

Specifically, the polarization member preferably used in the present invention transmits only the light of which the electric vector oscillates in a direction of a tangent line of a circle centering around an optical axis of the projection optical system.

[0007]

[Effects]

Referring to FIG. 2, the effect of the present invention will be described. FIG. 2 is a view schematically illustrating the shape of a diffracted light in the neighborhood of an image surface 23 of the aligner as described above with reference to FIG. 3. First, FIG. 2(a) shows a light state called a TE (Transverse Electric) polarization that corresponds to the light of which the oscillation direction of an electric vector is transverse to an incident surface (e.g., an inner surface of the sheet). On the other hand, FIG. 2(b) shows a light state called a TM (Transverse Magnetic) polarization that corresponds to the light of which the oscillation direction of a magnetic vector is transverse to an incident surface, in other words, of which the oscillation direction of the electric vector is inside the incident surface. In a conventional device provided with a projection optical system that does not include a polarization member, an image is formed by the light in an average state of the TE polarization as shown in FIG. 2(a) and the TM polarization as shown in FIG. 2(b). However, since the photochemical reaction of a photosensitive material such as photoresist is performed by the effect of electric field of the light that is an electromagnetic wave, the oscillation direction of the electric vector may cause

[0008]

As can be seen from Figs. 2(a) and 2(b), in the case of TE polarization, the oscillation directions of electric vectors of respective diffracted lights of the 0^{th} degree, $\pm 1^{st}$ degree, and so forth, are arranged to be transverse to the sheet, the interference effect among the diffracted lights becomes maximum, and thus a high-contrast image is formed. In the case of TM polarization, the oscillation directions of electric vectors of diffracted lights having different degrees deviate from one another depending on the angles formed by the propagating directions of the respective diffracted lights, the interference effect among the diffracted lights deteriorates, and thus the contrast of the image is degraded.

[0009]

In the present invention, since the polarization member is arranged approximately on a pupil surfacepupil plane of the projection optical system to transmit only the light of which an electric vector oscillates in a direction parallel to sides of the pattern formed on the photo mask, the diffracted light in a non-polarized state, being generated from the photo mask, is converted into the TE polarization having an oscillation surface that is

transverse to the plane (i.e., incident surface) forming the diffraction angle, and thus an image having a high contrast can be obtained.

[0010]

Here, since the arrangement direction of an actual circuit pattern formed on the photo mask may differ and the circuit pattern may include an isolated pattern such as a hole pattern in addition to a line-and-space pattern repeating in a specified period, it is preferable to use the polarization member that transmits only the light of which the electric vector oscillates in the direction of the tangent line of a circle centering around the optical axis of the projection optical system. Using this polarization member, only the light of which the electric vector oscillates in the direction parallel to the sides of the pattern can be transmitted through the polarization member irrespective of the arrangement direction of the pattern.

[0011]

On the other hand, for easier understanding of the description, it is assumed that the line-and-space pattern (i.e., the pattern in which the light shield part and the light transmission part are alternately repeated with the same width) extending in a direction transverse to the sheet is formed on the photo mask 21, and the pattern image is formed by the 0^{th} and $\pm 1^{st}$ degree diffracted lights among the diffracted lights from the photo mask 21. In this case, the 0^{th} degree diffracted light has an amplitude of 1/2, and the $\pm 1^{st}$ degree diffracted light has an amplitude of $1/\pi$.

[0012]

As shown in FIG. 2, if it is assumed that x (i.e., left/right direction on the sheet), y (i.e., vertical direction on the sheet) and z (i.e., upward/downward direction on the sheet) coordinate axes are set, the direction cosine of the 0^{th} degree diffracted light is set to $(0, 0, 1)$, the direction cosine of the $\pm 1^{st}$ degree diffracted light is set to $(\pm\alpha, 0, \gamma)$, and the waves (vector amount) of the 0^{th} and $\pm 1^{st}$ degree diffracted lights are denoted as Ψ_0 and $\Psi_{\pm 1}$, the waves of the respective diffracted lights in the case of TE polarization are expressed as in Equations (1) to (3). In the equations, k is an integer ($=2\pi/\lambda$).

[0013]

[Expression 1]

$$\phi_0 = \frac{1}{2}\begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} e^{ik(0x+0y+1z)} \qquad \ldots\ldots \text{(Equation 1)}$$

$$\phi_1 = \frac{1}{\pi}\begin{bmatrix}0\\1\\0\end{bmatrix}e^{ik(\alpha x+0y+\gamma z)} \qquad \ldots\ldots \text{(Equation 2)}$$

$$\phi_{-1}= \frac{1}{\pi}\begin{bmatrix}0\\1\\0\end{bmatrix}e^{ik(-\alpha x+0y+\gamma z)} \qquad \ldots\ldots \text{(Equation 3)}$$

[0014]

The wave field (Ψ_{TE}) obtained by adding the waves (Ψ_0, $\Psi_{\pm1}$) of the 0^{th} and $\pm1^{st}$ degree diffracted lights is expressed in Equation (4), and the strength distribution $I_{TE}(x,z)=|\Psi|^2$ is expressed in Equation (5).

[0015]

[Expression 2]

$$\psi_{TE} = \begin{bmatrix}0\\1\\0\end{bmatrix}\left[\frac{1}{2}e^{ikZ} + \frac{1}{\pi}e^{ik\gamma Z}\left(e^{ik\alpha x} + ex^{-ik\alpha x}\right)\right] \qquad \ldots\ldots \text{(Equation 4)}$$

$$I_{TE(x,z)} = \frac{1}{4} + \frac{2}{\pi}\cos(k\alpha x)\bullet\cos\{k(1-\gamma)z\} + \frac{4}{\pi^2}\cos^2(k\alpha x) \qquad \ldots\ldots \text{(Equation 5)}$$

[0016]

On the other hand, in the case of TM polarization, the waves of the respective diffracted lights are expressed in Equations (6) to (8).

[0017]

[Expression 3]

$$\phi_0= \frac{1}{2}\begin{bmatrix}1\\0\\0\end{bmatrix}e^{ikz} \qquad \ldots\ldots \text{(Equation 6)}$$

$$\phi_1 = \frac{1}{\pi}\begin{bmatrix}\gamma\\0\\-\alpha\end{bmatrix}e^{ik(\alpha x+0y+\gamma z)} \qquad \ldots\ldots \text{(Equation 7)}$$

$$\phi_{-1} = \frac{1}{\pi}\begin{bmatrix}\gamma \\ 0 \\ \alpha\end{bmatrix} e^{ik(-\alpha x+0y+\gamma z)} \qquad \text{...... (Equation 8)}$$

[0018]

The wave field (Ψ_{TM}) obtained by adding the waves (Ψ_0, $\Psi_{\pm 1}$) of the 0th and ±1st degree diffracted lights is expressed in Equation (9), and the strength distribution $I_{TM}(x,z) = |\Psi|^2$ is expressed in Equation (10).

[0019]

[Expression 4]

$$\psi_{TE} = \left[\frac{1}{2}e^{ikz} + \frac{1}{\pi}\gamma e^{ik\gamma z}\left(e^{ik\alpha x} + e^{-ik\alpha x}\right) - \frac{1}{\pi}\alpha e^{ik\gamma Z}\left(e^{ik\alpha x} - e^{-ik\alpha x}\right)\right] \qquad \text{...... (Equation 9)}$$

$$I_{TE(X,Z)} = \frac{1}{4} + \frac{2}{\pi}\gamma\cos(k\alpha x)\bullet\cos\{k(1-\gamma)z\} + \frac{4}{\pi^2}\{\alpha^2 + (\gamma^2 - \alpha^2)\cos^2(k\alpha x)\} \text{(Equation 10)}$$

[0020]

Here, as a valuation index, a log slope value is considered. This log slope value is a differential value when a logarithm of strength I on the boundary of geometrical optics contrast is obtained. If this value is large, the image has a high contrast. In Equations (5) and (10), the log slope values in the case of TE polarization and TM polarization can be calculated. If it is assumed that Z=0 on the best focus surface, the log slope value LS_{TE} in the case of TE polarization is obtained from Equation (11), and the log slope value LS_{TM} in the case of TM polarization is obtained from Equation (12). In addition, the log slope value in a non-polarization state corresponds to an average state of the TE polarization and the TM polarization.

[0021]

[Expression 5]

$$LS_{TE} = \frac{4\lambda}{\alpha} \qquad \text{...... (Equation 11)}$$

$$LS_{TE} = \frac{4\lambda}{\alpha}\bullet\frac{\sqrt{1-\alpha^2}}{1+16\alpha^2/\pi^2} \qquad \text{...... (Equation 12)}$$

[0022]

In the term related to $4\lambda/\alpha$ in Equation (12), since the numerator is smaller than "1" and the denominator is larger than "1", it is understood that the value of Equation

(12) is smaller than the value of Equation (11) as a whole. This indicates that the image formed in the case of TE polarization has a log slope value higher than the image formed in the case of TM polarization. Also, since α corresponds to the diffraction angle, the superiority of the TE polarization is extended as the fine pattern has a higher diffraction angle.

[0023]

In addition, since the non-polarization state is the average state of the TE polarization and the TM polarization, the image formed by the TE polarization has the log slope value higher than that of the image formed by the non-polarization, and thus has a high contrast. Also, since the polarization and the phase of the light refer to independent information, a phase shift mask may be used in the aligner according to the present invention, and a much higher improvement of the image forming performance can be achieved by properly combining three kinds of information such as amplitude, phase and polarization of the light.

[0024]

[Embodiments of the Invention]

FIG. 1 is a view schematically illustrating the construction of an aligner according to an embodiment of the present invention. In the drawing, an illumination optical system 4 employs a super high voltage mercury lamp or an excimer laser as a light source, and emits an exposure light having a wavelength that can sensitize a photoresist used in a lithography cycleprocess.

[0025]

The photo mask 1 is maintained in a horizontal plane to be transverse to an optical axis of an illumination optical system 4. Although the shape of the pattern formed on the photo mask 1 is not specially limited, it is exemplified that, for detailed explanation, a line-and-space pattern in which an optical transmission part and a light shield part such as chrome are alternately repeated is formed, and the pattern is extended in a direction that is transverse to the sheet surface.

[0026]

On the lower side of the photo mask 1, a projection optical system 2 is arranged, and its position in an optical-axis direction is adjusted so that the light source (i.e., illumination optical system 4) side focus of the projection optical system 2 is approximately in accord with the pattern formed surface of the photo mask 1. On the

pupil surfacepupil plane (strictly, it is not required that the pupil surfacepupil plane is the pupil position) of the projection optical system 2, as shown in FIG. 1(b), a polarization member 5, which transmits only the light of which the electric vector oscillates in a direction of the tangent line of a concentric circle centering around the optical axis (i.e., the center of the pupil) of the projection optical system 2, is arranged.

[0027]

On the lower side of the projection optical system 2, a wafer stage (not illustrated) on which a wafer (not illustrated) is placed is installed, and its position on the optical axis is adjusted so that the image forming surface 3 of the projection optical system 2 is in accord with the wafer surface. Also, the wafer stage is movable in the horizontal surface, and the relative positions of the wafer and the photo mask 1 are adjusted using an alignment means (not illustrated) before the exposure operation.

[0028]

In the aligner having the above-described construction, if when the photo mask 1 is transparently illuminated by an exposure light from the illumination optical system 4, as shown in FIG. 1(a), a diffracted light that is widened in the left/right direction on the sheet from the photo mask 1 is generated. In this stage, the diffracted light is in an average state of the TE polarization and the TM polarization, and has no slope in the oscillation direction.

[0029]

Then, the diffracted light is incident to the projection optical system 2, and then reaches the polarization member 5 arranged on the pupil surfacepupil plane. Here, the 0^{th} degree diffracted light among the diffracted lights from the photo mask 1 is incident to the center of the pupil (i.e., the polarization member 5) of the projection optical system 2 irrespective of the pattern forming position (whether the pattern is positioned in the center part or end part of the illumination region. The diffracted lights of the 0^{th} degree, $\pm 1^{st}$ degree, and so forth, are incident to positions apart from each other for a specified distance in a radius direction (i.e., the direction of the pattern arrangement) from the pupil center. In the embodiment of the present invention, if the pattern arrangement direction is the left/right direction on the sheet, the incident positions of the respective diffracted lights to the polarization member 5 are arranged at predetermined intervals on the diameter crossing a circle (See FIG. 1(b)) centering around the optical axis of the projection optical system 2 in the left/right direction. As described above, since the

polarization member 5 transmits only the light of which an electric vector oscillates in a direction of the tangent line of a circle centering around the optical axis of the projection optical system 2, only the components of the respective diffracted lights of which electric vectors oscillate in upward/downward direction of FIG. 1(b) can be transmitted through the polarization member 5.

[0030]

In this case, the polarization state of the light being transmitted in the center of the polarization member 5 as shown in FIG. 1(b) becomes unstable, and thus it is preferable to shift the incident position of the 0^{th} diffracted light from the center of the polarization member 5. This can be easily realized by making ring beltannular illumination through the shielding of the center part of the light source of the illumination optical system 4. That is, by making the ring beltannular illumination, the photo mask 1 is illuminated in a direction slightly sloping from the vertical direction (i.e., the optical axis direction). Since the 0^{th} diffracted light is incident to a position sloping in a radius direction from the center of the polarization member 5 as much as the portion corresponding to the slope (at this time, the positions of the other diffracted lights are slanted to an outside of the radius direction in the order of their degree, the lights having different oscillation directions is prevented from being transmitted through the polarization member 5.

[0031]

Referring again to FIG. 1(a), the exposure light having passed through the polarization member 5 of the projection optical system 2 becomes the TE polarization in which the oscillation direction of the electric vector is arranged in the vertical direction (i.e., the direction parallel to the sides of the pattern), and an image of the line-and-space pattern of the photo mask 1 is formed on the image forming surface 3. By this, the transfer of the pattern is performed in a specified position of the wafer maintained on the image forming surface 3.

[0032]

In the embodiment of the present invention, the image is formed only by the light of which the oscillation direction is arranged as described above, the interference effect among the diffracted lights is increased, and thus an image having a high contrast is transferred onto the wafer surface. In addition, since the diffraction angle of the diffracted light of which the degree is not less than the first degree is increased as the

pattern pitch becomes smaller, the contrast of the image deteriorates as much as the deviation of the oscillation direction of the TM polarization in the case where the image is formed in a non-polarized state (i.e., TE polarization + TM polarization) as in the conventional device. However, in the case where the image is formed only by the TE polarization as in the embodiment of the present invention, the oscillation direction of the electric vector is not changed even if the diffraction angle is changed, and thus a high contrast is maintained. That is, by using the aligner having the structure illustrated in FIG. 1, a high-contrast image can be obtained although the pitch of the pattern becomes very small, and the superiority of the TE polarization against the conventional aligner is extended as the fine pattern has a higher diffraction angle.

[0033]

For convenience in explanation, it is exemplified that the pattern of the photo mask 1 is arranged in the left/right direction on the sheet. However, the high-contrast image can be obtained in the same manner even if the arrangement direction differs. The aligner according to embodiments of the present invention can cope with all kinds of patterns. In other words, although the direction in which the diffracted light is widened is changed and the arrangement direction of the incident position of the respective diffracted light on the pupil surfacepupil plane of the projection optical system 2 is changed (e.g., if the arrangement direction of the pattern is the upward/downward direction on the sheet as shown in FIG. 1(b), the incident position of the respective diffracted light is arranged on the diameter that crosses the concentric circle as shown in FIG. 1(b) in the upward/downward direction) as the arrangement direction of the pattern is changed, only the light of which the electric vector oscillates in a direction parallel to the sides of the pattern is always transmitted through the polarization member 5 even if the pattern is arranged in any direction.

[0034]

By contrast, if when the arrangement direction of the pattern is limited in one direction, the polarization member 5 (See FIG. 1(b)) of which the oscillation direction of the light being transmitted by the position in the direction of the circumference of a circle may not be used. In this case, it is preferable to use the polarization member that transmits only the light of which the electric vector oscillates in the same direction (i.e., the direction parallel to the sides of the pattern) irrespective of the incident position. Table 1 below shows the results of obtaining the log slope values of the pattern on the

best focus surface obtained in the respective polarization states (e.g., TE polarization, TM polarization, and average of TE polarization and TM polarization) from equations 11 and 12 in a state that the exposure wavelength is λ=365nm. As the results from Table 1, it is clear that the superiority of the present invention can be exhibited as the fine pattern has a higher diffraction angle. For example, in manufacturing a high density integration semiconductor device such as 64M DRAM and so on, it can be understood that the aligner according to the present invention is quite effective.

[0035]

[Table 1]

Line Width (L/S)	TE	TM	Average
0.7μm	11.429	9.938	10.683
0.6μm	13.333	11.045	12.189
0.5μm	16.000	12.250	14.125
0.4μm	20.000	13.307	16.653
0.3μm	26.667	13.229	19.948

[0036]

In the embodiment of the present invention, it is exemplified that the photo mask has a pattern formed only by a light shield. However, the aligner according to the present invention may be used in combination with a phase shift mask. In addition to a space frequency modulation type in which a phase shift member is added to one side of a light transparent part through a light shield part, for example, the type disclosed in Japanese Patent Laid-open No. Sho 62-50811, diverse types of phase shift masks have been proposed, such as a multistage type in which phase member having different widths are installed, an auxiliary pattern type in which an auxiliary pattern composed of a phase shift member is installed on the periphery of the light shield pattern, an edge emphasis type in which a phase shift member is installed on the boundary between a light shield part and a light transmission part, a chromeless type in which a pattern is formed only by a phase shift member, and so forth. The aligner according to the present invention can be combined with any type of phase shift mask.

[0037]

Also, in the above description, it is exemplified that a transmission type photo mask is used. However, the present invention can also be applied to a case that a reflection type photo mask having a reflection member (reflection film) installed on a

transparent substrate is used. In the reflection type mask, the image is formed by performing an auxiliary lighting of the photo mask and collecting the reflected light from the reflection film in an image-forming optical system, and the light transmission part and the light reflection part correspond to the dark part and the bright part of the image, respectively. However, by installing a polarization member that transmits the light of which the electric vector oscillates in a direction parallel to the sides of the pattern on the pupil surfacepupil plane of the image-forming optical system, the contrast of the image can be heightened in the same manner as the case of using the transmission mask.

[0038]

[Effect of the Invention]

As described above, according to the aligner according to the present invention, since the polarization member, which transmits only the light of which the electric vector oscillates in a direction parallel to the sides of the pattern to be transferred, is installed on the pupil surfacepupil plane of the projection optical system, an image is formed by the light of which the oscillation direction of the electric vector is arranged in the same direction, the interference among the diffracted lights is increased, and thus a high-contrast image can be obtained.

[0039]

In addition, according to the present invention, since a fine circuit pattern is provided and a high contrast can be maintained even if the diffraction angle of the light from the photo mask becomes larger, the superiority of the present invention against the conventional aligner can be exhibited as the fine pattern has a higher diffraction angle. Also, the aligner according to the present invention can form an image using three kinds of information, such as amplitude, phase, and polarization, of the light combined with a phase shift mask recently developed, and is very effective in seeking the new development of a lithography technology.

[Brief Description of the Drawings]

[FIG. 1] (a) is a view illustrating the structure of an aligner according to an embodiment of the present invention, and (b) is a schematic plan view of a polarization member used in the embodiment of the present invention.

[FIG. 2] (a) and (b) are conceptual views explaining image forming types by TE polarization and TM polarization, respectively.

[FIG. 3] is a view illustrating the structure of a conventional aligner.

[Description of Reference Numerals]

1	Photo Mask
2	Projection Optical System
3	Image Forming Surface
4	Illumination Optical System
5	Polarization Member

[Amendment]

[Date of submission] June 25, 1999

[Amendment 1]

[Document subject to amendment] Specification

[Item subject to amendment] Title of invention

[Contents of amendment]

[Title of invention] Aligner and exposure method thereof

[Amendment 2]

[Document subject to amendment] Specification

[Type of amendment] Modification

[Contents of amendment]

[What is claimed is:]

[Claim 1] An aligner having a projection optical system that projects a pattern on a photo mask, the aligner comprising a polarization member, arranged approximately on a pupil surfacepupil plane of the projection optical system, for transmitting light of which an electric vector oscillates in a direction parallel to sides of the pattern.

[Claim 2] The aligner of claim 1, wherein the polarization member transmits only the light of which the electric vector oscillates in a direction of a tangent line of a circle centering around an optical axis of the projection optical system.

[Claim 3] An exposure method for an aligner having a projection optical system that projects a pattern on a photo mask, the exposure method comprising arranging a polarization member for transmitting light, of which an electric vector oscillates in a direction parallel to sides of the pattern, approximately on a pupil surfacepupil plane of the projection optical system, and transferring the pattern onto the photo mask using the aligner.

[Amendment 3]

[Document subject to amendment] Specification

[Item subject to amendment] 0004

[Type of amendment] Modification

[Contents of amendment]

[0004]

However, this phase shift method itself has limitations, and fails to provide a satisfactory high-contrast image of the fine pattern. The present invention has been

developed in order to substantially solve the above and other problems associated with the conventional arrangement. An object of the present invention is to provide an aligner which can realize a high-resolution, high-contrast image forming performance using third information except for the amplitude and the phase of light and thus can make it possible to seek a new development of the photolithography technology, and an exposure method which transfers a pattern onto a photo mask using the aligner.

[Amendment 4]

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[Contents of amendment]

[0006]

Specifically, the polarization member preferably used in the present invention transmits only the light of which the electric vector oscillates in a direction of a tangent line of a circle centering around an optical axis of the projection optical system. In addition, the aligner according to the present invention is provided with a projection optical system that projects a pattern onto a photo mask, and in order to solve the above-described problems, there is provided an exposure method for the aligner which comprises arranging a polarization member for transmitting light, of which an electric vector oscillates in a direction parallel to sides of the pattern, approximately on a pupil surfacepupil plane of the projection optical system, and transferring the pattern onto the photo mask using the aligner.

[Procedural Amendment Document]

[Date of Submission] September 9, 1992

[Procedural Amendment 1]

[Document to be Amended] Specification

[Item to be Amended] 0003

[Type of Amendment] Modification

[Contents of Amendment]

[0003]

[Problem to be Solved by the Invention]

With the conventional aligner as described above, however, it is impossible to cope with a fine circuit pattern according to the high density integration of a semiconductor device, and there exists a need for the development of technology that makes it possible to form a high-contrast image of a fine pattern. As a method for heightening the contrast on a pattern, for example, Japanese Patent Laid-open No. S62-50811 discloses a phase shift method that performs projection exposure using a phase shift mask having a phase shift part installed in a specified place of a light transmission part of a photo mask to change the phase of a transmitted light. This phase shift method forms a pattern image using phase information of light in addition to amplitude information of the light. For example, this phase shift method achieves somewhat improvement of the image forming performance in comparison to a method that used a photo mask composed of a light transmission part (e.g., naked surface part of a substrate) and a light shield part only.

[Procedural Amendment 2]
[Document to be Amended] Specification
[Item to be Amended] 0033
[Type of Amendment] Modification
[Contents of Amendment]
[0033]

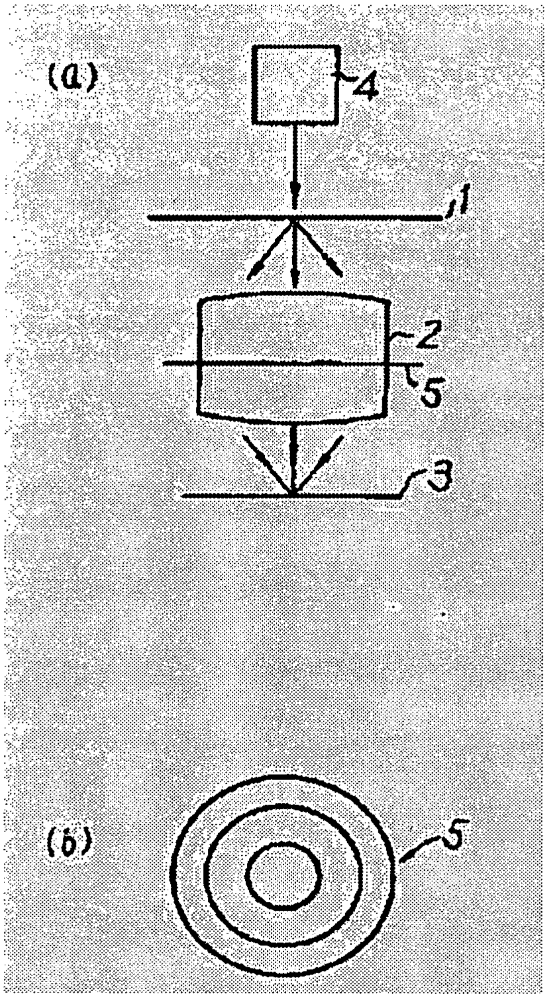
For convenience in explanation, it is exemplified that the pattern of the photo mask 1 is arranged in the left/right direction on the sheet. However, the high-contrast image can be obtained in the same manner even if the arrangement direction differs. The aligner according to embodiments of the present invention can cope with all kinds of patterns. In other words, although the direction in which the diffracted light is widened is changed and the arrangement direction of the incident position of the respective diffracted light on the pupil surfacepupil plane of the projection optical system 2 is changed (e.g., if the arrangement direction of the pattern is the upward/downward direction on the sheet as shown in FIG. 1(b), the incident position of the respective diffracted light is arranged on the diameter that crosses the concentric circle as shown in FIG. 1(b) in the upward/downward direction) as the arrangement direction of the pattern is changed, only the light of which the electric vector oscillates in a direction parallel to the sides of the pattern is always transmitted through the polarization member 5 even if

the pattern is arranged in any direction.

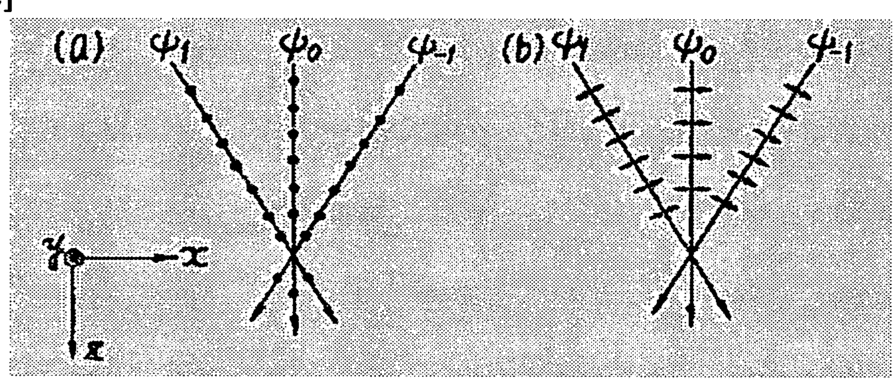
[Procedural Amendment 3]
[Document to be Amended] Specification
[Item to be Amended] 0036
[Type of Amendment] Modification
[Contents of Amendment]
[0036]

In the embodiment of the present invention, it is exemplified that the photo mask has a pattern formed only by a light shield. However, the aligner according to the present invention may be used in combination with a phase shift mask. In addition to a space frequency modulation type in which a phase shift member is added to one side of a light transparent part through a light shield part, diverse types of phase shift masks have been proposed, such as a multistage type in which phase member having different widths are installed, an auxiliary pattern type in which an auxiliary pattern composed of a phase shift member is installed on the periphery of the light shield pattern, an edge emphasis type in which a phase shift member is installed on the boundary between a light shield part and a light transmission part, a chromeless type in which a pattern is formed only by a phase shift member, and so forth. The aligner according to the present invention can be combined with any type of phase shift mask.

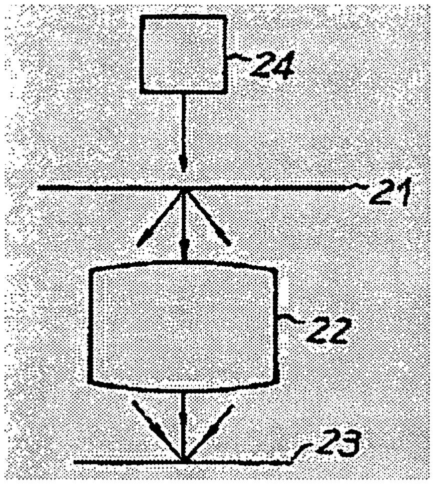
[Fig. 1]



[Fig. 2]



【Fig. 3】



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(71)出願人　000004112
株式会社ニコン
東京都千代田区丸の内３丁目２番３号

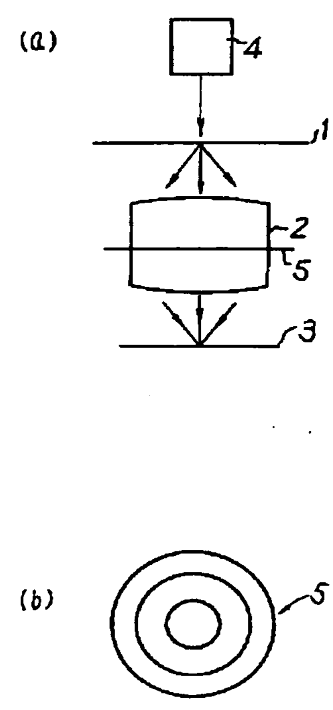
(72)発明者　松本　宏一
東京都品川区西大井１丁目６番３号　株式会社ニコン大井製作所内

(54)【発明の名称】　露光装置

(57)【要約】

【目的】　微細パターンの高コントラストの像を得ることのできる露光装置を提供する。

【構成】　照明光学系４は、好ましくは光源の中心部が遮蔽された輪帯照明の構成をとっており、パターン形成されたフォトマスク１を所定波長の露光光で透過照明する。フォトマスク１の下方には投影光学系２が設けられており、この投影光学系２の瞳面には、フォトマスク１のパターンの辺と平行な方向に電気ベクトルが振動する光のみを透過させる偏光部材５が配置されている。フォトマスク１が透過照明されることにより生じた回折光は投影光学系２で集められ、偏光部材５によって電気ベクトルの振動方向が揃ったTE偏光に変換され、像面３にパターン像を形成する。



【特許請求の範囲】
【請求項１】 フォトマスク上のパターンを投影する投影光学系を備えた露光装置において、前記投影光学系のほぼ瞳面に、前記パターンの辺と平行な方向に電気ベクトルが振動している光を透過させる偏光部材が配置されたことを特徴とする露光装置。
【請求項２】 前記偏光部材は、前記投影光学系の光軸を中心とする円の接線方向に電気ベクトルが振動している光のみを透過させるものであることを特徴とする請求項１記載の露光装置。
【発明の詳細な説明】
【０００１】
【産業上の利用分野】本発明は、半導体素子製造のリソグラフィ工程において、フォトマスクに形成された回路パターンの像をウエハ面に転写するために用いられる露光装置に関するものである。
【０００２】
【従来の技術】半導体素子製造のリソグラフィ工程において一般的に用いられている露光装置は、図３に示されるような構成であった。図において、フォトマスク21は、照明光学系24の光軸に対して直交するように水平に保持されており、照明光学系24から射出された所定波長の露光光によって透過照明される。従来から汎用されているフォトマスク21は、透明基板上にクロム等の金属からなる遮光パターンが形成された構造をなしており、透過照明されることによって、パターン形状に応じた回折光が発生する。これらの回折光は、投影光学系22により再度、像面23上に集められ、これにより結像面23に合致するように保持されたウエハ面上にフォトマスク21のパターン像が転写される。この際、従来の露光装置の投影光学系には、偏光部材は含まれていないので、像面23に集められる光は、偏光特性のない状態、つまり、ＴＥ偏光（後述）とＴＭ偏光（後述）の平均状態になっている。
【０００３】
【発明が解決しようとする課題】ところで、上記のような従来の露光装置においては、半導体素子の高集積化に伴なう回路パターンの微細化に対応できないという問題点があり、微細パターンの高コントラストの像を形成できる技術の開発が求められている。こうした中で、パターン像のコントラストを高める方法として、近年、フォトマスクの光透過部の特定の箇所に透過光の位相を変化させる位相シフト部を設けた位相シフトマスクを用いて投影露光を行なう位相シフト法が種々提案されている。例えば、特公昭62－ 50811 号公報には、空間周波数変調型の位相シフトマスクに関する技術が開示されている。位相シフト法は、光の振幅の情報に加えて光の位相の情報を利用してパターン像を形成するものであり、光透過部（基板裸面部）と遮光部だけからなるフォトマスクを使用する方法に比べればある程度の結像性能の改善が実現されている。
【０００４】しかしながら、この位相シフト法にも自ら限界があり、微細パターンについて満足すべき高コントラストの像は得られていない。この発明は、かかる点に鑑みてなされたものであり、光の振幅と位相以外の第三の情報を利用することにより、高解像性・高コントラストの結像性能を実現でき、光リソグラフィー技術の新たな展開を図ることが可能な露光装置を提供することを目的とするものである。
【０００５】
【課題を解決するための手段】本発明の露光装置は、フォトマスク上のパターンを投影する投影光学系を備えており、上記の課題を達成するために、前記投影光学系のほぼ瞳面に、前記パターンの辺と平行な方向に電気ベクトルが振動している光を透過させる偏光部材が配置されたものである。
【０００６】本発明で好ましく用いられる偏光部材は、具体的には、前記投影光学系の光軸を中心とする円の接線方向に電気ベクトルが振動している光のみを透過させるものである。
【０００７】
【作用】図２を参照して本発明の作用を説明する。図２は、図３で説明した露光装置の像面23付近の回折光の様子を模式的に示したものである。まず、図２（ａ）は、ＴＥ(transverse electric）偏光と呼ばれる状態であり、電気ベクトルの振動方向が入射面（紙面内面）に垂直な光である。一方、図２（ｂ）はＴＭ（transverse magnetic)偏光と呼ばれる状態であり、磁気ベクトルの振動方向が入射面に垂直、即ち、電気ベクトルの振動方向が入射内面にある。投影光学系に偏光部材を含まない従来の装置では、図２（ａ）のＴＥ偏光と図２（ｂ）のＴＭ偏光の平均状態の光で結像されることになるが、フォトレジスト等の感光材料の光化学反応は電磁波である光の電場の作用によって進行するので、リソグラフィ工程においては電気ベクトルの振動方向が問題となる。
【０００８】図２（ａ）と図２（ｂ）を比較すると解るように、ＴＥ偏光の場合は、０次、±１次･･･の各回折光の電気ベクトルの振動方向が全て紙面に垂直な方向にそろっており、回折光同志の干渉効果が最大となって、高コントラストの像となる。ＴＭ偏光の場合は、次数の異なる回折光の電気ベクトルの振動方向は各回折光の進行方向のなす角に応じた分だけずれることになり、回折光同志の干渉効果が低減して、像のコントラストを落とす方向に作用する。
【０００９】本発明においては、投影光学系のほぼ瞳位置に、フォトマスクに形成されたパターンの辺に平行な方向に電気ベクトルが振動する光のみを透過させる偏光部材が配置されているので、フォトマスクで発生した非偏光状態の回折光は、回折角を形成する平面（入射面）に直交する振動面を有するＴＥ偏光に変換され、コント

ラストの高い像が得られる。

【００１０】ここで、フォトマスクに形成される実際の回路パターンの配列方向はさまざまであり、一定の周期で繰り返されるラインアンドスペースパターンの他にホールパターン等の孤立パターンも含まれるから、本発明で用いる偏光部材としては、投影光学系の光軸を中心とする円の接線方向に電気ベクトルが振動している光のみを透過させるものを用いることが好ましい。このような偏光部材を用いれば、パターンがどのような方向に配列されていても、常にパターンの辺と平行な方向に電気ベクトルが振動する光のみが偏光部材を透過することになる。

【００１１】さて、次に、更に説明を解りやすくするために、フォトマスク21に紙面垂直方向に伸長するラインアンドスペースパターン（遮光部と光透過部が同じ幅で交互に繰り返されるパターン）が設けられており、フォトマスク21からの回折光のうち０次回折光と±１次回折光によりパターン像が形成される場合を考える。この場合、０次回折光の振幅は１／２、±１次回折光の振幅は１／πである。

【００１２】図２に示してある様に、ｘ（紙面左右方向），ｙ（紙面垂直方向），ｚ（紙面上下方向）座標軸を設定し、０次回折光の方向余弦を（０，０，１）、±１次回折光の方向余弦を（±α，０，γ）として、０次回折光、±１次回折光の波動（ベクトル量）をψ_0、$\psi_{\pm 1}$とすると、ＴＥ偏光の場合の各回折光の波動は式１～３で表わされる。式中ｋは定数（＝２π／λ）である。

【００１３】

【数１】

$$\phi_0 = \frac{1}{2}\begin{pmatrix}0\\1\\0\end{pmatrix} e^{ik(0x+0y+1z)} \quad \cdots\cdots\cdots\cdots 式1$$

$$\phi_1 = \frac{1}{\pi}\begin{pmatrix}0\\1\\0\end{pmatrix} e^{ik(\alpha x+0y+\gamma z)} \quad \cdots\cdots\cdots\cdots 式2$$

$$\phi_{-1} = \frac{1}{\pi}\begin{pmatrix}0\\1\\0\end{pmatrix} e^{ik(-\alpha x+0y+\gamma z)} \quad \cdots\cdots\cdots\cdots 式3$$

【００１４】０次回折光及び±１次回折光の波動ψ_0，$\psi_{\pm 1}$を合成した波動場Ψ_{TE}は式４となり、強度分布I_{TE}（ｘ，ｚ）＝$|\Psi|^2$は、式５となる。

【００１５】

【数２】

$$\Psi_{TE} = \begin{pmatrix}0\\1\\0\end{pmatrix}\left[\frac{1}{2}e^{ikz} + \frac{1}{\pi}e^{ik\gamma z}\left(e^{ik\alpha x} + e^{-ik\alpha x}\right)\right] \quad \cdots\cdots\cdots\cdots 式4$$

$$I_{TE}(x,z) = \frac{1}{4} + \frac{2}{\pi}\cos(k\alpha x)\cdot\cos\{k(1-\gamma)z\} + \frac{4}{\pi^2}\cos^2(k\alpha x) \quad \cdots\cdots\cdots\cdots 式5$$

【００１６】一方、ＴＭ偏光の場合の各回折光の波動は式６～８で表わされる。

【００１７】

【数３】

$$\phi_0 = \frac{1}{2}\begin{pmatrix}1\\0\\0\end{pmatrix} e^{ikz} \quad \cdots\cdots\cdots\cdots 式６$$

$$\phi_1 = \frac{1}{\pi}\begin{pmatrix}\gamma\\0\\-\alpha\end{pmatrix} e^{ik(\alpha x+0y+\gamma z)} \quad \cdots\cdots\cdots 式７$$

$$\phi_{-1} = \frac{1}{\pi}\begin{pmatrix}\gamma\\0\\\alpha\end{pmatrix} e^{ik(-\alpha x+0y+\gamma z)} \quad \cdots\cdots\cdots\cdots 式８$$

【００１８】０次回折光及び±１次回折光の波動ψ_0，$\psi_{\pm1}$を合成した波動場Ψ_{TM}は、式９となり、強度分布$I_{TM}(x, z) = |\Psi|^2$は、式10となる。

【００１９】

【数４】

$$\Psi_{TM} = \begin{pmatrix} \frac{1}{2} e^{ikz} + \frac{1}{\pi}\gamma e^{ik\gamma z}(e^{ik\alpha x} + e^{-ik\alpha x}) \\ 0 \\ -\frac{1}{\pi}\alpha e^{ik\gamma z}(e^{ik\alpha x} - e^{-ik\alpha x}) \end{pmatrix}$$

$$\cdots\cdots\cdots\cdots\cdots 式９$$

$$I_{TM}(x, z) = \frac{1}{4} + \frac{2}{\pi}\gamma\cos(k\alpha x)\cdot\cos\{k(1-\gamma)z\} + \frac{4}{\pi^2}\left\{\alpha^2 + (\gamma^2-\alpha^2)\cos^2(k\alpha x)\right\}$$

$$\cdots\cdots\cdots\cdots\cdots 式１０$$

【００２０】ここで、像の評価指標として、ログ・スロープ(log slope) 値を考える。このログ・スロープ値とは、幾何光学的な明暗の境界における強度Ｉの対数をとった時の微分値であり、即ち$\partial \log I / \partial x$の値である。そして、この値が大きい方が、いわゆる高コントラストの像であることを示している。式５と式10より、おのおのＴＥ偏光、ＴＭ偏光の時のログ・スロープ値を計算できる。簡単のため、ベスト・フォーカス面にて考えるものとして、Ｚ＝０として計算すると、ＴＥ偏光のときのログ・スロープ値LS_{TE}は式11、ＴＭ偏光のときのログ・スロープ値LS_{TM}は式12となる。また非偏光状態のときのログ・スロープ値は、ＴＥ偏光とＴＭ偏光の平均状態である。

【００２１】

【数５】

$$LS_{TE} = \frac{4\lambda}{\alpha} \quad \cdots\cdots\cdots\cdots\cdots 式１１$$

$$LS_{TM} = \frac{4\lambda}{\alpha} \cdot \frac{\sqrt{1-\alpha^2}}{1+16\alpha^2/\pi^2} \quad \cdots\cdots\cdots 式１２$$

【００２２】式12のうち、$4\lambda/\alpha$に掛かっている項を考えると、分子は１より小さく、分母は１より大きいので、全体として式12の値は、式11の値より小さいことが理解される。このことは、ＴＥ偏光での結像の方が、ＴＭ偏光での結像よりも高いログ・スロープ値を有していることを示している。また、αは回折角に対応するの

で、回折角の大きい微細パターン程、ＴＥ偏光の優位性は大きくなる。

【００２３】更に、非偏光状態は、ＴＥ偏光とＴＭ偏光の平均状態であるから、ＴＥ偏光による結像は、当然、非偏光による結像より、高いログ・スロープ値を有していて、いわゆる高コントラストな像を達成することになる。また、光の偏光と位相は独立した情報であるから、本発明の露光装置に位相シフトマスクを用いることもでき、光の振幅，位相，偏光の３つの情報を適宜組み合わせることにより結像性能の一層の向上を図ることが可能である。

【００２４】

【実施例】図１は、本発明実施例による露光装置の構成を模式的に示した構成図である。図において、照明光学系４は、超高圧水銀ランプ，エキシマレーザ等を光源とし、リソグラフィ行程で使用されるフォトレジストを感光させ得る波長の露光光を射出する。

【００２５】フォトマスク１は、照明光学系４の光軸と直交するように、水平面内に保持されている。フォトマスク１に形成されるパターンの形状は特に限定されるものではないが、ここでは、説明を具体的にするために、光透過部とクロム等の遮光部が交互に繰り返されるいわゆるラインアンドスペースパターンが形成されており、パターンは紙面と垂直な方向に伸長しているものとする。

【００２６】フォトマスク１の下方には、投影光学系２が配置されており、投影光学系２の光源（照明光学系４）側焦点とフォトマスク１のパターン形成面がほぼ一致するように光軸方向の位置が調整されている。この投影光学系２の瞳面（厳密に瞳位置である必要はない）には、図１（ｂ）に示されているように、投影光学系２の光軸（瞳中心）を中心とした同心円の接線方向に電気ベクトルが振動する光のみを透過させる偏光部材５が配置されている。

【００２７】投影光学系２の下方には、ウエハ（図示せず）を載置するウエハステージ（図示せず）が設けられ、投影光学系２の結像面３とウエハ表面とが合致するように、光軸上の位置が調整されている。また、ウエハステージは、水平面内にも移動可能となっており、露光に先立ち、不図示のアライメント手段を用いてウエハとフォトマスク１の相対的位置の調整が行なわれる。

【００２８】上述した構成の露光装置において、照明光学系４からの露光光によってフォトマスク１が透過照明されると、図１（ａ）に示されるようにフォトマスク１からは、紙面内左右方向（パターンの配列方向）に広がる回折光が発生する。この段階で回折光は、ＴＥ偏光とＴＭ偏光の状態が平均された状態であり、振動方向の偏りはない。

【００２９】次いで、回折光は投影光学系２に入射し、瞳面に配置された偏光部材５に至る。ここで、フォトマスク１からの回折光のうち０次回折光は、パターンの形成位置によらず（パターンが照明領域の中央部になっても端にあっても）、投影光学系２の瞳中心（偏光部材５中心）に入射し、±１次，±２次，・・・の各回折光は、瞳中心から半径方向（パターン配列方向）に所定距離ずつ離れた位置に入射する。本実施例のように、パターンの配列方向が紙面左右方向である場合は、各次数の回折光の偏光部材５への入射位置は、投影光学系２の光軸を中心とした円（図１（ｂ）参照）を紙面左右方向に横切る直径上に所定の間隔で並ぶことになる。偏光部材５は、上述したように、投影光学系２の光軸を中心とした円の接線方向に電気ベクトルが振動する光のみを透過させるものであるから、各次数の回折光はそれぞれ図１（ｂ）の上下方向に電気ベクトルが振動する成分のみが偏光部材５を透過することになる。

【００３０】この際、図１（ｂ）のような偏光部材５の中心においては、透過する光の偏光状態が不安定になるため、０次回折光の入射位置を偏光部材５の中心から偏位させることが望ましい。このことは、照明光学系４の光源の中心部を遮蔽して輪帯照明とすることで容易に実現される。即ち、輪帯照明とすることで、フォトマスク１は、垂直方向（光軸方向）から僅かに傾いた方向から照明されることになり、０次回折光は傾きに応じた分だけ偏光部材５の中心から半径方向にずれた位置に入射することになるので（このとき１次以上の回折光の位置も順に半径方向外側にずれる）、振動方向の異なる光が偏光部材５を透過することを防止できる。

【００３１】図１（ａ）に戻って、投影光学系２の偏光部材５を透過した露光光は、電気ベクトルの振動方向が紙面垂直方向（パターンの辺と平行な方向）に揃ったＴＥ偏光となり、結像面３にフォトマスク１のラインアンドスペースパターンの像を結ぶ。これにより、結像面３に保持されたウエハの所定の位置にパターン像の転写が行なわれる。

【００３２】本実施例では、上述のようにして、振動方向の揃った光だけで像が形成されるので、回折光同志の干渉効果が増し、コントラストの高い像がウエハ面に転写される。また、パターンピッチが小さくなる程１次以上の回折光の回折角が大きくなるため、従来のように、非偏光状態（ＴＥ偏光＋ＴＭ偏光）の光で結像される場合は、ＴＭ偏光の振動方向のずれが大きくなる分だけ像のコントラストが低下することになるが、本実施例のようにＴＥ偏光だけで結像される場合は、回折角が変わっても電気ベクトルの振動方向は変わらないので、高いコントラストが維持される。即ち、図１のような構造の露光装置を用いることにより、パターンのピッチが非常に小さくなっても高コントラストの像を得ることができ、微細パターン程、従来の露光装置に対する優位性が明確になる。

【００３３】なお、上記においては、説明のためにフォ

トマスク１のパターンは紙面左右方向に配列されているとしたが、配列方向が他の方向であっても同様にコントラストの高い像を得ることができることは言うまでもなく、本実施例の露光装置はあらゆる形状のパターンに対応できる。つまり、パターンの配列方向が変われば、それに対応して回折光の広がる方向が変わり、投影光学系２の瞳面における各次数の回折光の入射位置の整列方向も変わるが（例えばパターンの配列方向が図１（ｂ）の紙面上下方向であれば、各次数の回折光の入射位置は図１（ｂ）の同心円を紙面上下方向に横切る直径上に整列する）、本実施例における偏光部材５は、図１（ｂ）の同心円の接線方向に振動面を有する光のみを透過させるものであるから、パターンがどのうよな方向に配列されていても常にパターンの辺と平行な方向に電気ベクトルが振動する光のみが偏光部材５を透過することになる。

【００３４】逆に、パターンの配列方向が一方向に限られているような場合は、円周方向の位置によって透過する光の振動方向が変わるような偏光部材５（図１（ｂ））を用いなくとも、入射位置によらず同じ方向（パターンの辺と平行な方向）に振動する光だけを透過させる偏光部材を用いれば良い。次に、例として、露光波長λ＝365 nmとして、式11～12から、各偏光状態（ＴＥ偏光，ＴＭ偏光，ＴＥ偏光とＴＭ偏光の平均）で得られるベスト・フォーカスでのパターン像のログ・スロープ値を求めた結果を示す。この表１の結果からも、微細パターン程、本発明の優位性が発揮されることが明らかであり、例えば64M DRAM等の集積度の高い半導体素子を製造するにあたって本発明の露光装置が非常に有効であることが理解される。

【００３５】

【表１】

線幅（Ｌ／Ｓ）	ＴＥ	ＴＭ	平均
0.7μm	11.429	9.938	10.683
0.6μm	13.333	11.045	12.189
0.5μm	16.000	12.250	14.125
0.4μm	20.000	13.307	16.653
0.3μm	26.667	13.229	19.948

【００３６】さて、上記においては、説明を簡単にするために、遮光膜だけでパターン形成されているフォトマスクを用いた場合について説明したが、本発明の露光装置は位相シフトマスクと組み合わせて使用することもできる。位相シフトマスクについては、遮光部を介して隣合う光透過部の一方に位相シフト部材を付加する空間周波数変調方式（例えば特公昭62－ 50811 号公報に記載の方式）の他、厚さの異なる位相部材を設ける多段方式、遮光パターンの周縁部に位相シフト部材からなる補助パターンを設ける補助パターン方式、遮光部と光透過部の境界に位相シフト部材を設けるエッジ強調方式、位相シフト部材だけでパターン形成するクロムレス方式等種々の方式が提案されているが、本発明は何れの方式の位相シフトマスクとも組み合わせることができる。

【００３７】また、上記の説明においては、透過型のフォトスマクを使用する場合について述べてきたが、本発明は、透明基板上に反射部材（反射膜）を設けた反射型のフォトマスクを使用する場合にも適用できるものである。反射型マスクにおいては、フォトマスクを落射照明して、反射膜からの反射光を結像光学系で集めることにより像が形成され、光透過部が像の暗部、反射部が像の明部に対応することになるが、結像光学系の瞳面にパターンの辺に平行な方向に電気ベクトルが振動する光を透過させる偏光部材を設けることにより、透過型マスクを用いる場合と同様に像のコントラストを高めることが可能である。

【００３８】

【発明の効果】以上の様に本発明の露光装置においては、転写すべきパターンの辺と平行な方向に電気ベクトルが振動する光のみを透過させる偏光部材を投影光学系の瞳面に設けているので、電気ベクトルの振動方向が同一方向に揃った光で像が形成されることになり、回折光同志の干渉が増し、コントラストの高い像を得ることができる。

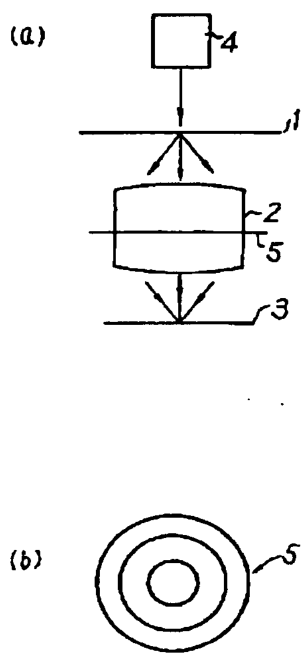
【００３９】また、本発明によれば、回路パターンが微細化してフォトマスクからの光の回折角が大きくなっても、高いコントラスを維持できるので、微細パターン程、従来の露光装置に対する優位性が発揮される。更に、本発明の露光装置は、近年開発された位相シフトマスクとの組み合わせて光の振幅，位相，偏光の３つの情報を利用して像を形成することができ、リソグラフィ技術の新たな展開を図る上で非常に有用である。

【図面の簡単な説明】

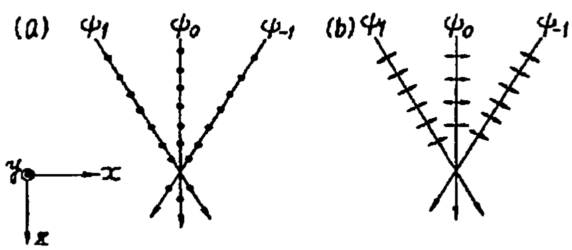
【図１】（ａ）は本発明実施例による露光装置の構造を示す構成図、（ｂ）は本発明実施例で使用した偏光部材の模式的な平面図である。

【図２】（ａ）,（ｂ）は、各々ＴＥ，ＴＭ偏光による結像の様子を示す概念図である。
【図３】従来の露光装置の構成を示す構成図である。
【主要部分の符号の説明】
1　フォトマスク
2　投影光学系
3　結像面
4　照明光学系
5　偏光部材

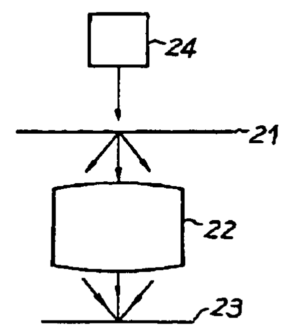
【図１】



【図２】



【図３】



【手続補正書】
【提出日】平成４年９月９日
【手続補正１】
【補正対象書類名】明細書
【補正対象項目名】０００３
【補正方法】変更
【補正内容】
【０００３】
【発明が解決しようとする課題】ところで、上記のような従来の露光装置においては、半導体素子の高集積化に伴なう回路パターンの微細化に対応できないという問題点があり、微細パターンの高コントラストの像を形成できる技術の開発が求められている。こうした中で、パターン像のコントラストを高める方法として、例えば特公昭62-50811号公報には、フォトマスクの光透過部の特定の箇所に透過光の位相を変化させる位相シフト部を設けた位相シフトマスクを用いて投影露光を行なう位相シフト法が開示されている。このような位相シフト法は、光の振幅の情報に加えて光の位相の情報を利用してパターン像を形成するものであり、例えば光透過部(基板裸面部) と遮光部だけからなるフォトマスクを使用する方法に比べればある程度の結像性能の改善が実現されている。
【手続補正２】
【補正対象書類名】明細書
【補正対象項目名】００３３
【補正方法】変更
【補正内容】
【００３３】なお、上記においては、説明のためにフォトマスク１のパターンは紙面左右方向に配列されているとしたが、配列方向が他の方向であっても同様にコントラストの高い像を得ることができることは言うまでもなく、本実施例の露光装置はあらゆる形状のパターンに対応できる。つまり、パターンの配列方向が変われば、それに対応して回折光の広がる方向が変わり、投影光学系２の瞳面における各次数の回折光の入射位置の整列方向も変わる（例えばパターンの配列方向が図１（ｂ）の紙面上下方向であれば、各次数の回折光の入射位置は図１（ｂ）の同心円を紙面上下方向に横切る直径上に整列する）が、本実施例における偏光部材５は、図１（ｂ）の同心円の接線方向に振動面を有する光のみを透過させる

ものであるから、パターンがどのような方向に配列されていても常にパターンの辺と平行な方向に電気ベクトルが振動する光のみが偏光部材５を透過することになる。
【手続補正３】
【補正対象書類名】明細書
【補正対象項目名】００３６
【補正方法】変更
【補正内容】
【００３６】さて、上記においては、説明を簡単にするために、遮光膜だけでパターン形成されているフォトマスクを用いた場合について説明したが、本発明の露光装置は位相シフトマスクと組み合わせて使用することもできる。位相シフトマスクについては、遮光部を介して隣合う光透過部の一方に位相シフト部材を付加する空間周波数変調方式の他、厚さの異なる位相部材を設ける多段方式、遮光パターンの周縁部に位相シフトマスク部材からなる補助パターンを設ける補助パターン方式、遮光部と光透過部の境界に位相シフト部材を設けるエッジ強調方式、位相シフト部材だけでパターン形成するクロムレス方式等、種々の方式が提案されているが、本発明は何れの方式の位相シフトマスクとも組み合わせることができる。